NEBRASKA DEPARTMENT OF ROADS
NDR STANDARD METHOD T 84

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE

Modifies
AASHTO Designation: T 84-93 I
ASTM Designation: C 128-88

SCOPE

1.1   This method covers the determination of bulk and apparent specific gravity   , 23/23°C(73.4/73.4°F), and absorption of fine aggregate.

1.2   This method determines (after 15 h in water) the bulk specific gravity and the apparent specific gravity, the bulk specific gravity on the basis of weight of saturated surface-dry aggregate, and the absorption as defined in AASHTO M 132.

1.3   The values stated i n SI units are to be regarded as the standard.

1.4   This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

APPLICABLE DOCUMENTS

2.1   **AASHTO Standards:**

   T 19   "Unit Weight and Voids in Aggregate"

   T 85   **"Specific Gravity and Absorption of Coarse Aggregate**

   T 133   "Density of Hydraulic Cement"

   T 142   "Surface Moisture in Fine Aggregate"

   M 231   "Weighing Devices Used in the Testing of Materials"

   T 255   **"Total Moisture Content of Aggregate by Drying"**

2.2   **ASTM Standards:**

C 125   "Terminology Relating to Concrete and Concrete Aggregates"

C 670   "Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials"

E 1   "Standard Specifications for ASTM Thermometers"

2.3   **NDR Standards:**

   T 2   ”Sampling Aggregates”

   T 248   ”Reducing Field Samples of Aggregate Testing Size”

   T 506   ”Determination of the Free Moisture Content of Aggregate”

SIGNIFICANCE AND USE

3.1   Bulk specific gravity is the characteristics generally used for calculation of the volume occupied by the aggregate in various mixtures containing aggregate including portland cement concrete, bituminous concrete, and other mixtures that are porportioned or analyzed on an absolute volume basis. Bulk specific gravity is also used in the computation of voids in aggregate in AASHTO T 19 and the determination of moisture in aggregate by displacement in water in AASHTO T 142. Bulk specific gravity determined on the saturated surface-dry basis is used if the aggregate is wet, that is, if its absorption has been satisfied. Conversely, the bulk specific gravity determined on the oven-dry basis is used for computations when the aggregate is dry or assumed to be dry.

3.2   Apparent specific gravity pertains to the relative density of the solid material making up the constituent particles not including the pore space within the particles that is accessible to water. This value is not widely used in construction aggregate technology.

3.3   Absorption values are used to calculate the change in the weight of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential.   The laboratory standard for absorption is that obtained after submerging dry aggregate for approximately 15 h in water   . Aggregates mined from below the water table may have a higher absorption when used, if not allowed to dry. Conversely, some aggregates when used may contain an amount of absorbed moisture less than the 15 h soaked condition: For an aggregate that has been in contact with water and that has free moisture on the particle surfaces, the percentage of free moisture can be determined by deducting the absorption from the total moisture content determined by NDR T 255 by drying.

APPARATUS

4.1   **Balance** - conforming to the requirements of AASHTO M 231, Class G2.

4.2   **Pycnometer** - a flask or other suitable container into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced with ±0.1 cm^3. The volume of the container filled to mark shall be at least 50 percent greater than the space required to accommodate the test sample A volumetric flask of 500 capacity or a fruit jar fitted with a pycnometer top is satisfactory for a 500-g test sample of most fine aggregates. A Le Chatelier flask as described in   AASHTO T 133 is satisfactory for an approximately 55-g test sample.

4.3   **Mold** - A metal mold is in the form of a frustum of a cone with dimensions as follows:
40 ± 3 mm inside diameter at the top, 90 ± 3 mm inside diameter at the bottom,
and 75 ± 3 mm in height, with the metal having a minimum thickness of 0.8 mm.

4.4   **Tamper** - A metal tamper weighing 340 ± 15 g and have a flat circular tamping face
25 ± 3 mm in diameter.

4.5   **Thermometers** - Calibrated liquid-in-glass, partial immersion of suitable range with
gradations to determine a temperature of 23 C ± 1°C and one to determine a temperature
of 110° C ± 5°C.

SAMPLING

5.1   Sampling shall be accomplished in general accordance with NDR T 2.

PREPARATION OF TEST SPECIMEN

6.1   Obtain approximately 1.3 kg of minus 3/8-inch sieve fine aggregate from the sample using
the applicable procedures described in AASHTO T 248. Discard the aggregate retained on the
3/8-inch sieve.

       6.1.1   Dry the sample in a suitable pan or vessel to constant weight at a temperature of
110 ± 5° C (230 ± 9° F). Allow it to cool to comfortable handling temperature,
cover with water and permit to stand for a minimum of 15 hours.

       6.1.2   As an alternative to Section 6.1.1, where the absorption and specific gravity
values are to be used in proportioning concrete mixtures with aggregates used in
their naturally moist condition, the requirement for initial drying to constant weight
may be eliminated and, if the surfaced of the particles have been kept wet, the
15 hour soaking may also be eliminated.

             Note 1: *Values for absorption and for specific gravity in the saturated surface-dry
condition may be significantly higher for aggregate not oven dried before soaking
than for the same aggregate treated in accordance withSection 6.1.1.*

6.2   Decant excess water with care to avoid loss of fines, spread the sample on a flat
nonabsorbant surface exposed to a gently moving current of warm air , and stir frequently
to secure homogeneous drying. If desired, mechanical aids such as tumbling or stirring
may be employed to assist in achieving the saturated surface-dry conditionA hot plate may
be used to initially dry the sample, care being taken not to dry any of the particles below
the saturated surface dry condition.

Continue this operation until the test specimen approaches a free-flowing condition. Follow
the procedure in Section 6.2.1 to determine whether or not surface moisture is present on
the constituent fine aggregate particles. It is intended that the first trial of the cone test will
be made with some surface water in the specimen. Continue drying with constant stirring
and test at frequent intervals until the test indicates that the specimen has reached a
surface-dry condition. If the first trial of the surface moisture test indicates that moisture is
not present on the surface, it has been dried past the saturated surface-dry condition. In
this case, thoroughly mix a few millilitres of water with the fine aggregate and permit the
specimen to stand in a covered container for 30 min. Then, resume the process of drying
and testing at frequent intervals for the onset of the surface-dry condition.

6.2.1 **Cone Test for Surface Moisture** - Hold the mold firmly on a smooth nonabsorbent surface with the large diameter down. Place a portion of the partially dried fine aggregate loosely in the mold by filling it to overflowing and heaping additional material above the top of the mold by holding it with the cupped fingers of the hand holding the mold. Tamp the fine aggregate into the mold with 25 light drops of the tamper. Each drop should start about 5mm (0.2 in.) above the top surface of the fine aggregate. Permit the tamper to fall freely under gravitational attraction on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Remove loose sand from the base and lift the mold vertically . If surface moisture is still present, the fine aggregate will retain the molded shape. When the fine aggregate slumps slightly, it indicates that it has reached a surface-dry condition. Some angular fine aggregate or material with a high proportion of fines may not slump in the cone test upon reaching a surface-dry condition. This may be the case if fines become airborne upon dropping a handful of the sand from the cone test 100 to 150 mm onto a surface. For these materials, the saturated surface-dry condition should be considered as the point that one side of the fine aggregate slumps slightly upon removing the mold.

> **Note 2**: *The following criteria have also been used on materials that do not readily slump:*

1. **Provisional Cone Test** - Fill the cone mold as described in Section 6.2.1 except only use 10 drops of the tamper . Add more fine aggregate and use 10 drops of the tamper again. Then, add material two more times using 3 and 2 drops of the tamper, respectively. Level off the material even with the top of the mold, remove loose material from the base; and lift the mold vertically .

2. **Provisional Surface Test** - If airborne fines are noted when the fine aggregate is such that it will not slump when it is at a moisture condition, add more moisture to the sand, and at the onset of the surface-dry condition, with the hand, lightly pat approximately 100 g of the material on a flat, dry , clean, dark or dull nonabsorbent surface such as a sheet of rubber, a worn oxidized, galvanized, or steel surface, or a black-painted metal surface. After 1 to 3 seconds, remove the fine aggregate. If noticeable moisture shows on the test surface for more than 1 to 2 seconds, then surface moisture is considered to be present on the fine aggregate.

3. Colorimetric procedures described by Kandhal and Lee, Highway Research Record No. 307, p. 44.

4. For reaching the saturated surface-dry condition on a single-size material that slumps when wet, hard-finish paper towels can be used to surface dry the material until the point is just reached where the paper towel does not appear to be picking up moisture from the surfaces of the fine aggregate particles.

PROCEDURES

7.1 Make and record all weight determinations to 0.1 g.

7.2 Partially fill the pycnometer with water . Immediately introduce into the pycnometer 500 ± 10 g of saturated surface-dry fine aggregate prepared as described in Section 6, and

fill with additional water to approximately 90 percent of capacity Roll, invert, and agitate the pycnometer to eliminate all air bubbles (Note 3).   Adjust its temperature to 23 ±   1.7° C (73.4 ± 3°F), if necessary by immersion in circulating water, and bring the water level in the pycnometer to its calibrated capacity. Determine total weight of the pycnometer, specimen, and water.

Note 3: *It normally takes about 15 to 20 minutes to eliminate air bubbles. Adding a few drops of isopropyl alcohol, after removal of air bubbles and just prior to bringing the water level to its calibrated capacity, has been found useful in dispersing foam on the water surface. Do not use this procedure when using the alternative method described in Section 7.2.1.*

7.2.1   **Alternative to Weighing in Section 7.2** - The quantity of added water necessary to fill the pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Compute the total weight of the pycnometer, specimen, and water as follows:

$$C = 0.9975 \, V_a + S + W$$

where:

C = weight of pycnometer with specimen and water to calibration mark, g,
V_a = volume of water added to pycnometer, mL
S = weight of saturated surface-dry specimen, g, and
W = weight of the pycnometer empty, g.

7.2.2   **Alternative to the Procedure in Section 7.2** - Use a Le Chatelier flask initially filled with water to a point on the stem between the 0 and the 1-mL mark. Record this initial reading with the flask and contents within the temperature range of 23 ± 1.7°C (73.4 ± 3F). Add 55 ± 5 g of fine aggregate in the saturated surface-dry condition (or other weight as necessary to result in raising the water level to some point on the upper series of graduation). After all fine aggregate has been introduced, place the stopper in the flask and roll the flask in an inclined position, or gently whirl it in a horizontal circle so as to dislodge all entrapped aircontinuing unti no further bubbles rise to the surface (Note 4). Take a final reading with the flask and contents within 1°C (1.8°F) of the original temperature.

Note 4: *When using the LeChatelier flask method, slowling adding a small measured amount (not to exceed 1 mL.) of isopropyl alcohol, after removal of air bubbles, has been found useful in dispersing foam appearing on the water surface. The volume of alcohol used must be subtracted from the final reading (R_2).*

7.3   Remove the fine aggregate from the pycnometer , dry to constant weight at a temperature of 110 ± 5°C (230 ± 9F), cook in air at room temperature and weigh.

7.3.1   If the Le Chatelier flask method is used, a separate sample portion is needed for the determination of absorption. W eigh a separate 500   ± 10 g portion of the saturated surface-dry fine aggregate, dry to constant weight, and reweigh.

7.4   Determine the weight of the pycnometer filled to its calibration capacity with water at 23 ± 1.7°C (73.4 ± 3°F).

7.4.1 **Alternative to Weighing in Section 7.4** - The quantity of water necessary to fill the empty pycnometer at the required temperature may be determined volumetrically using a buret accurate to 0.15 mL. Calculate the weight of the pycnometer filled with water as follows:

$$B = 0.9975 \, V + W$$

where:

B = weight of flask filled with water, g,
V = volume of flask, mL, and
W = weight of the flask empty, g.

BULK SPECIFIC GRAVITY

8.1 Calculate the bulk specific gravity, 23/23C (73.4/73.4F), as defined in AASHTO M 132 as follows:

$$\text{Bulk sp gr} = A \, / \, (B + S - C)$$

where:

A = weight of oven-dry specimen in air, g,
B = weight of pycnometer filled with water, g,
C = weight of pycnometer with specimen and water to calibration mark, g, and
S = weight of saturated surface-dry specimen, g.

8.1.1 If the Le Catelier flask method was used, calculate the bulk specific gravity, 23/23°, as follows:

$$\text{Bulk Sp. Gr.} = \frac{S_1(A/S)}{09975 \, (R_2 - R_1)}$$

where:

R_1 = initial reading of water level in Le Chatelier flask,
R_2 = final reading of water level in Le Chatelier flask, and
S_1 = weight of saturated surface-dry specimen used in Le Chatelier flask, g.

BULK SPECIFIC GRAVITY (SATURATED SURFACE-DRY BASIS)

9.1 Calculate the bulk specific gravity, 23/23°C (73.4/73.4°F), on the basis of weight of saturated surface-dry aggregate as follows:

Bulk sp gr (saturated surface-dry basis)

$$= S \, / \, (B + S - C)$$

9.1.1   If the Le Chatelier flask method was used, calculate the bulk specific gravity   ,
23/23°C, on the basis of saturated surface-dry aggregate as follows:

Bulk sp gr (saturated surface-dry basis)

$$= \frac{S_1}{09975\ (R_2 - R_1)}$$

APPARENT SPECIFIC GRAVITY

10.1   Calcualte the apparent specific gravity, 23/23C (73.4/73.4F), as defined in AASHTO M 132
as follows:

Apparent sp gr $= A / (B + A - C)$

ABSORPTION

11.1   Calculate the percentage of absorption, as defined in ASTM C 125, as follows:

Absorption, % $= [\ (S - A) / A\ ] \times 100$

REPORT

12.1   Report specific gravity results to the nearest 0.01 and absorption to the nearest 0.1 percent.
The appendix gives mathematical interrelationships among the three types of specific
gravities and absorption. These may be useful in checking the consistency of reported data
or calculating a value that was not reported by using other reported data.

12.2   If the fine aggregate was tested in a naturally moist condition other than the oven dried and
15-hour soaked condition, report the source of the sample and the procedures used to
prevent drying prior to testing.

PRECISON AND BIAS

13.1   The esitmates of precision of this test method (listed in Table 1) are based on results from
the AASHTO Materials Reference Laboratory Reference Sample Program, with testing
conducted by this test method and   ASTM C 128. The significant dif ference between the
methods is that ASTM C 128 requires a saturation period of 24 ±4 hours, and T 84 requires
a saturation period of 15 to 19 hours.   This dif ference has been found to have an
insignificant effect on the precision indices. The data are based on the analyses of more
than 100 paired test results from 40 to 100 laboratories.

13.2   Since there is no accepted reference material suitable for determining the bias for the
procedure in   T 84 for measuring specific gravity and absorption of fine aggregate, no
statement on bias is being made.

Table 1 Precision

	Standard Deviation (1S)[A]	Acceptable Range of Two Results (D2S)[A]
Single Operator Precision:		
Bulk specific gravity (dry)	*0.011*	*0.032*
Bulk specific gravity (SSD)	*0.0095*	*0.027*
Apparent specific gravity	*0.0095*	*0.027*
Absorption[B], percent	*0.11*	*0.31*
Multilaboratory Precision:		
Bulk specific gravity (dry)	*0.023*	*0.066*
Bulk specific gravity (SSD)	*0.020*	*0.056*
Apparent specific gravity	*0.020*	*0.056*
Absorption[B], percent	*0.23*	*0.660*

[A] These numbers represent, respectively, the (1S) and D2S) limits as described in ASTM C 670. The precision estimates were obtained from the analysis of combined AASHTO Materials Reference Laboratory reference sample data from laboratories using 15- to 19-hour saturation times and other laboratories using 24 ± 4 hours saturation time. Testing was performed on normal weight aggregates, and started with aggregates in the oven-dry condition.

[B] Precision estimates are based on aggregates with absorptions of less than 1 percent and may differ for manufacturered fine aggregates and fine aggregates having absorption values greater than 1 percent.

APPENDIX (Nonmandatory Information)

X1.   Interrelationships between specific gravities and absorption as defined in Methods   T 84 and T 85

X1.1   Let:

S_d = bulk specific gravity (dry-basis),
S_s = bulk specific gravity (SSD-basis),
S_a = apparent specific gravity, and
A = absorption in percent

Then:

(1) $S_d = (1 + A / 100) S_d$

(2) $S_a = \dfrac{1}{1 - \dfrac{A}{S_d} \quad \dfrac{}{100}} = \dfrac{S_d}{1 - \dfrac{AS_d}{100}}$

or

(2a) $S_a = \dfrac{1}{\dfrac{1 + A/100}{S_s} \quad \dfrac{A}{100}}$

$= \dfrac{S_s}{1 - \dfrac{A}{100} (S_s - 1)}$

(3) $A = \left(\dfrac{S_s}{S_d} - 1 \right) 100$

(4) $A = \left(\dfrac{S_s - S_s}{S_d \, (S_s - 1)} \right) 100$